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A Report On

Aquatic Monitoring Of The 1975 Spruce Budworm Fenitrothion Aerial Spray Project In Washington State

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DANIEL J. EVANS
GOVERNOR

DEPARTMENT OF ECOLOGY
JOHN A. BIGGS
DIRECTOR

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A REPORT ON:

AQUATIC MONITORING
OF THE 1975 SPRUCE BUDWORM FENITROTHION
AERIAL SPRAY PROJECT
IN
WASHINGTON STATE

Prepared By
Harry B. Tracy
Biologist

and

Bill Purvis
Contractor

Department of Ecology
Olympia, Washington
98504

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INTRODUCTION

During the summer of 1975 nine 2-square mile plots of forested land in the Okanogan and Wenatchee National Forests of Washington State were scheduled to be sprayed with the organophosphate insecticide Fenitrothion* to test the efficiency of the chemical against the western spruce budworm. The Washington State Department of Ecology was contracted by the U.S. Forest Service (USFS) to collect samples for residue analysis and to monitor the impacts of the Fenitrothion on the aquatic environment.

Fenitrothion residue monitoring and impact studies conducted by the Department of Ecology (DOE) were financed under Contract Number 004799N issued by the USFS. The $35,500 contract dated June 3, 1975 stipulated that the DOE would analyze for the incidence of Fenitrothion in the aquatic environment through sample analysis and assess the impacts, if any, of Fenitrothion on aquatic organisms.

BACKGROUND

The initial outbreak of the western spruce budworm occurred on the eastern slope of the Cascade Mountains in 1969 - 1970 involving some 20,000 acres of the Wenatchee and Okanogan National Forests. By 1974 over 500,000 acres were heavily infested with further spreading inevitable.

Spruce Budworm Life Cycle

Briefly, the spruce budworm attacks Douglas fir and white fir. The larvae hatch in the spring and feed on the buds and new needles of the target trees until they pupate in the late summer. The adults emerge and swarm in the fall laying eggs in cocoons which hatch in the spring.

Although the spruce budworm is attacked by viruses, their populations do not seem to experience a massive collapse in numbers the third year as do the tussock moth infestations. Spruce budworms seem to be hardier insects and more persistent with a greater tendency for spreading into other areas.

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* Manufactured by the Sumitomo Chemical Company, Japan. It is also known as Sumithion (O, O-dimethyl O-3-methyl-4-nitrophenyl phosphorothionate)

Aerial Spray Project

The aerial spray project was planned, implemented and supervised by the USFS. Cascade Helicopters Inc., of Cashmere, Washington was employed to apply the chemical using helicopters.

Nine 2-square mile blocks of forested land were selected for study (Figures 1, 2, and 3). Major spray areas consisting of three 2-square mile blocks each were located near the towns of Cle Elum in The Wenatchee National Forest and Twisp and Mazama in the Okanogan National Forest. Three blocks received one application of Fenitrothion at three ounces per acre (1 + 3), three blocks received two applications at two ounces per acre (2 + 2), and the remaining three blocks served as controls. Final determinations were made by random drawing with the following results:

Table 1. Test block application rates; 1975 Spruce Budworm Fenitrothion Aerial Spray Project. Department of Ecology, 1975.

Area	Block A	Block B	Block C
Cle Elum	2 + 2	2 + 2	Control
Twisp	2 + 2	1 +3	1 + 3
Mazama	1 + 3	Control	Control

Diesel oil carrier was added to the Fenitrothion in a quantity (17 oz. or 18 oz.) required to bring the total application to 20 ounces per acre. Streams in the spray blocks were not buffered.

Aquatic Monitoring Preparations

Two contract employees and one intern were hired on the project bringing the DOE field sampling staff to a total of seven.

Most of the field sampling equipment that was obtained for the 1974 Tussock Moth DDT Aerial Spray Project was serviceable for the Fenitrothion Project, with minor repairs (Tracy 1975). Some additional equipment such as sample bottles, insect live boxes, and insect screens were ordered or fabricated. A 16-foot travel trailer was rented which served as a field laboratory and an auxiliary generator was obtained to provide electrical power for the fluorescent lights in the 10-power magnifying glasses that were used for sample processing.

The fish shockers were repaired as necessary and new batteries for the electro-fishers were purchased. A flow meter for measuring water velocity was purchased and additional miscellaneous equipment was bought to outfit three drift sampling stations over the usual one station equipped on previous studies. By June 1, all of the materials on order had arrived, repairs to sampling gear had been completed, and the field crews were equipped and ready for the prespray sampling run.

OBJECTIVES

Primary objectives of the aquatic monitoring phase of the 1975 Fenitrothion Aerial Spray Project were two-fold: 1) to analyze for and assess the incidence of Fenitrothion residues in the aquatic environment and 2) to assess the impacts, if any, on the aquatic environment of the Fenitrothion applied during the program. The study also would provide baseline data for the index streams such as fish densities, benthic invertebrate populations, stream drift organisms, stream flows, etc.

METHODS

The basic mechanics of the 1975 Spruce Budworm Fenitrothion Aerial Spray Project and the 1974 Tussock Moth DDT Aerial Spray Project, were quite similar. For the most part, the methods employed in both studies were taken from "Monitoring the 1964 Spruce Budworm Aerial Spray Project" by Casebeer, (Casebeer, 1965).

The residue sampling techniques employed on both studies were identical, however, drift insect sampling was conducted at all three stations during the 1975 program in an effort to show the impacts of the chemical as it moved downstream. Also, drift insect samples collected on spraydays were processed immediately to provide the USFS with a continuous and up-to-the-minute evaluation of the impacts of the aerial spray project.

GENERAL

The project was conducted in duplicate. Two index streams were selected in blocks that received one application at three ounces per acre (1 + 3) and two index streams were selected in blocks that received two applications one week apart at two ounces per acre (2 + 2).

Three sampling stations were established on each index stream. The distance between each station was approximately one quarter mile, however, dye tests were conducted to insure that between station flow time exceeded 10 minutes, the duration of the drift sampling period.

Two nonspray stations were established on streams that would not be affected by the chemical spray in each of the two major spray areas, Cle Elum and Twisp. One sampling station each on the east and west forks of Buttermilk Creek located in Sec. 26, T. 33N, R. 20E., and Sec. 36, T. 33N, R. 20E, respectively, served as controls for the Twisp spray blocks. One station on Jack Creek, tributary of the Teanaway River, located in Sec. 4, T. 21 N, R. 16E, and one station on the upper Teanaway River in Sec. 11, T. 22 N, R. 14E, served as controls for the Cle Elum area streams. A schematic showing the sampling station layout and the samples collected at each index stream and nonspray sampling station is shown in Figure 4.

Sampling Schedule

Index and control streams were selected during the week of May 5, 1975. Suitable streams were available in the Cle Elum and Twisp spray areas minimizing logistics and travel time since the two controls and one 1 + 3 block near Mazama were not monitored (Figure 3).

Prespray sampling of all index streams and control stations was conducted over the period extending from June 9 to June 15. By June 16, the field samplers were ready for the first sprayday.

The following is a resume of the times, dates, and sampling station locations of the streams that were monitored during the 1975 Spruce Budworm Aerial Spray Project:

TABLE 2. Spray dates, application rates, locations and streams that were monitored during the 1975 Spruce Budworm Fenitrothion Aerial Spray Project; Department of Ecology, 1975.

Stream	Spray Day	Area	Location	Rate/ Acre	Application
Alder Cr.	6/25	Twisp	Sec. 25, T33N, R21E	2 oz.	1 of 2
Teanaway R.	6/30	Cle Elum	Sec. 19, T22N, R16E	2 oz.	1 of 2
Stafford Cr.	7/1	Cle Elum	Sec. 26, T22N, R16E	2 oz.	1 of 2
Libby Cr.	7/6	Twisp	Sec. 17, T32N, R21E	3 oz.	1 of 1
Teanaway R.	7/7	Cle Elum	Sec. 19, T22N, R16E	2 oz.	2 of 2
Stafford Cr.	7/8	Cle Elum	Sec. 26, T22N, R16E	2 oz.	2 of 2
Poormans Cr.	7/9	Twisp	Sec. 30, T33N, R21E	3 oz.	1 of 1

Alder Creek was not a program stream; however, one station was monitored on it's June 25 sprayday as a training exercise since it flowed from the first block that was sprayed. The remainder of the watercourses listed were program streams and were sprayed when USFS entomologists determined that 70 percent of the spruce budworms had reached the 5th instar stage in development. As expected, most of the spray blocks ripened simultaneously, therefore, Libby, Teanaway, Stafford, and Poormans creeks were sprayed on four consecutive days.

MATERIALS AND EQUIPMENT

The following materials and equipment were used on the various project phases as indicated:

Residue Sampling

Sterilized tin cans or glass jars in quart, pint, and one-half pint sizes were used to contain the fish and benthic samples for Fenitrothion residue analyses. Water samples destined for residue analysis were shipped to the laboratory in one quart glass jars.

Fish Collections

The Smith Root Type VII Battery Powered Back Pack Electro Fisher, manufactured by Smith Root Inc., 14014 NE Salmon Creek Avenue, Vancouver, Washington was used to stun fish for capture.

Quantitative Benthic Samples

A modified Neil Cylinder (R. M. Neil, 1938), manufactured by Allied Plastic Fabricators Inc., Seattle, Washington, fabricated from fiberglass tubing that encompassed a 2-square foot area was used for collecting benthic square foot samples.

Drift Insect Samples

Drift nets utilized during the impact study were manufactured by the Wildlife Supply Company, Saginaw, Michigan 40682. The nets measured 39 inches long with a 12-inch by 18-inch opening. They were fabricated from No. 54 (363 micron) mesh nylon with a metal plankton bucket. Net openings were framed with 3/8-inch steel bar stock and steel support stakes were provided.

Fish Live Boxes

Fish live boxes were fabricated from thin-wall fiberglass tubing, 16 inches in diameter and 18 inches long. The ends were covered with 1/8-inch mesh nylon net held in place with rubber straps cut from automobile inner tubes.

Insect Live Boxes

Insect live boxes eight inches long and three inches in diameter were fabricated from PVC pipe. The ends were enclosed with fine mesh netting held in place with stainless steel hose clamps. A longitudinal plastic separator divided each live box into two compartments.

Parameters

A prepared chemistry kit was used for analyzing water samples. In addition, stream flow, air and water temperatures, and weather conditions were recorded using appropriate instruments.

FIELD PROCEDURES

Fenitrothion Residue Sampling

Because of its rapid degrading characteristics, sampling for Fenitrothion residues was limited. Benthic organisms, fish, and water were the three principle sample types collected for Fenitrothion residue analysis as shown in Figure 4.

Prespray and postspray samples of each material were collected from each nonspray and index sampling station. Fish and benthic grab samples were collected 24 to 48 hours after termination of spraying to allow exposure time to the spray chemical. Water grab samples were collected every one-half hour for hourly composites commencing at midnight and terminating at noon on sprayday.

Samples were packed in ice and transported daily to the Department of Ecology Laboratory in Redmond, Washington for chemical extractions. Environmental Protection Agency chemists conducted the gas chromatograph analyses.

Impact Studies

The impact studies were directed at assessing the impacts, if any, on the aquatic environment of the Fenitrothion aerial spray application. This phase of the overall monitoring program involved five distinct field projects as follows:

1) Drift insect sampling
2) Quantitative benthic sampling
3) Fish live box studies
4) Insect live box studies
5) Stream surveys.

Fish populations in the limited number of streams that flowed from the spray blocks were either depressed or nonexistent; Therefore, fish density studies were not conducted on this project.

A brief description of each of the five field studies follows. More detailed information is available from the Department of Ecology Water Quality Management Division, Olympia, Washington 98504.

Drift Insect Sampling. Drift insect sampling provided a quantitative measurement of the insects adrift in the flowing stream. Prespray and postspray drift insect samples were collected from all index stream stations, and from all nonspray stations. Drift nets were set in pairs for 10 minutes of each hour over the 12-hour period commencing at midnight and terminating at noon the following day. On Poormans Creek the entire flow was filtered through a single drift net. Drift net contents were placed in sample jars and fixed in 70 percent ethyl alcohol solution. Prespray and postspray samples were transported to the Department of Ecology, Olympia laboratory for processing, however sprayday samples were counted immediately and the results were reported in terms of insects per 100 cubic feet of flow through the drift nets.

Quantitative Benthic Sampling. Benthic sampling provided a quantitative measurement of the invertebrates inhabiting the stream substrate before and after sprayday. Using the 2-square foot sampler, the substrate within the confines of the cylinder was agitated allowing the current to carry the dislodged invertebrates through the opening and into the collection net. The agitation process was conducted three times in three different locations providing a 6-square foot sample. Three such 6-square foot samples were collected at all index and nonspray stations during the prespray sampling sortie and 24-48 hours after sprayday. The contents of the nets were transfered into sample jars which were properly labeled and transported to the DOE Olympia Laboratory for processing.

Fish Live Box Studies. One fish live box containing 15 rainbow trout was placed in each index stream and at each nonspray station during the

prespray sampling run and removed during the postspray sampling run. Live box fish also were used for Fenitrothion residue analysis in streams that did not contain fish populations.

The rainbow trout that served as test organisms in the live boxes were obtained from the Washington State Department of Game, Tokul Creek Hatchery, near North Bend, Washington.

Insect Live Box Studies. Insect larvae, primarily of the Orders Plecoptera and Ephemeroptera, were captured and acclimated for approximately 24 hours. Approximately two to four hours before the aerial spray application, 10 stoneflies and 10 mayflies were placed in separate compartments of seven insect live boxes. Two insect-ladened live boxes were placed in the stream at each index stream station and one live box was placed in a control stream.

Twelve hours after exposure the insect live boxes were retrieved. Live and dead insects were counted by Order and the data was recorded in field notebooks.

Stream Surveys. Stream surveys were conducted immediately prior to the aerial spray application and immediately thereafter. The prespray survey consisted of examining stream conditions in the vicinity of, and above, the sampling stations to insure that no phenomenon was occurring that may alter stream conditions in a manner that would affect the impact study in progress. In addition, the survey included a check of the stream waters and adjacent areas for any unusual signs such as dead or dying fish, insects, birds, etc. The surveyor also placed oil sensitive spray cards along the stream from about 100 yards above Station #1 throughout the study area to about 100 yards below Station #3.

Postspray stream surveyors reexamined the area as described and retrieved the spray cards which demonstrated the concentration and distribution of the spray.

Essentially all of the field and laboratory work relating to the impact assessments of the Fenitrothion Aerial Spray Project in the aquatic environment was accomplished by Department of Ecology personnel.

RESULTS

RESIDUE SAMPLING

Fenitrothion residue data extracted from the fish and insect samples that were collected during the 1975 Spruce Budworm Fenitrothion Aerial Spray Project are not presented in this report. A limited amount of residue information taken from the water samples is shown graphically in Figures 6, 7, 8, 10, 11, and 12. The Spruce Budworm Project Fenitrothion residue data processing runs that are available may be obtained from the Department of Ecology, Olympia, Washington 98504 or from the U.S. Forest Service, Portland, Oregon.

IMPACT STUDIES

Only data from two of the six program stream spraydays will be presented here.

Data from Libby Creek, the Twisp area 1 + 3 stream, will not be shown because it flowed through a deep gorge under a heavy canopy and spray cards placed along the stream bank indicated that little if any of the chemical spray entered the stream. Fenitrothion concentrations in the Libby Creek water samples did not rise above one part per billion.

Stafford Creek, a 2 + 2 program stream in the Cle Elum area, is a tributary of the Teanaway River and the two streams have similar flow and habitat characteristics. Data collected during both spraydays on each of the two streams also is very similar; therefore, Teanaway River sprayday II will be presented in this report to represent the 2 + 2 stream data group.

Poormans Creek, a 1 + 3 Twisp area stream, will be shown to represent the 1 + 3 data group. Any additional data presentation would only belabor the subject and add little if any productive information.

Data from the other program streams is available from the Department of Ecology on request.

Teanaway River

The Teanaway River received two applications of Fenitrothion seven days apart at two ounces per acre. The data shown here was collected during the second sprayday which occurred July 7, 1975.

Drift Insects. The drift insect sampling data show increased activity in the aquatic biota resulting from the Fenitrothion aerial spray application (Figures 6, 7, and 8).

Spray sensitive cards placed along the river bank indicated that the chemical spray did enter the stream, particularly in the open areas. Spraying commenced at approximately 0500 hours with the initial application beginning on the high ridges, working down into the draws and completing the spray block in the vicinity of the aquatic monitoring sampling stations between 0700 and 0900 hours.

Figures 6, 7, and 8 show Fenitrothion concentrations in the Teanaway water samples below detection levels from 0000 hours until about 0600 hours when concentrations climbed to 6.7, 4.0, and 3.0 ug/l at Stations #1, #2, and #3, respectively. The increase in Fenitrothion levels appears to bring about an increase in insect activity in the stream which is manifested by a slight rise in the drift insect sample counts. For instance, at Station #2 (Figure 7), the normal downward trend in insect counts beginning at dawn (about 0400 hours) is obvious continuing until 0800 hours shortly after Fenitrothion concentrations peak. The drift insect sample counts rise from 8.0 insects per 100 cubic feet of flow at 0800 hours to 12.1 insects/100 ft^3 at 1200 hours.

The picture at Station #1 (Figure 6) and Station #3 (Figure 8) is similar. A pronounced and normal downward trend in drift insect sample counts beginning at dawn followed by an increasing trend concurrent with a rise in Fenitrothion concentrations. Most of the drift insect sprayday data also show a decline in counts when the chemical concentrations return to subdetection levels.

Although these trends are somewhat subtle, they do appear quite consistently throughout the program stream sprayday data. Furthermore, insect diversity alterations in the sprayday drift sampling data add strength to the contention that the Fenitrothion aerial spray application caused increased insect activity among the aquatic biota.

The following table shows each of the Teanaway River drift insect sample collection periods; prespray, sprayday II, (Stations #1, #2, and #3) and postspray; as individual samples. The 13 10-minute drift samples that were collected hourly during each period were averaged by Order and totaled. The average percent contribution of insects by Order in those samples also was computed and tabulated:

Table 3. Average insect counts and average insect percent contribution by Order in the Teanaway River prespray, sprayday II (Stations #1, #2, #3) and postspray drift insect samples. Department of Ecology, 1975.

		Ephemeroptera		Diptera		Trichoptera		Plecoptera		Coleoptera		Totals	
Run	Date	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Prespray	6/12	29.3	69.9	10.2	24.4	1.7	4.0	0.6	1.5	0.1	0.2	41.9	100
Sta. #1	7/7	72.9	79.4	13.8	15.1	1.4	1.5	3.1	3.3	0.6	0.7	91.8	100
Sta. #2	7/7	106.9	73.1	30.2	20.7	2.2	1.5	5.8	4.0	1.0	0.7	146.2	100
Sta. #3	7/7	67.4	71.5	20.8	22.1	2.0	2.1	3.1	3.6	0.6	0.6	94.2	99.9
Postspray	7/23	117.1	72.1	38.6	23.7	2.5	1.6	3.2	2.0	0.9	0.6	162.3	100

These data show a definite increase in the contribution percentage of Ephemeroptera over prespray levels at Station #1 (79.4%) where Fenitrothion concentrations reached the highest (6.7 ug/1) of the three stations. Mayfly contribution also increased above prespray levels at Station #2, where Fenitrothion concentrations reached 4.0 ug/1, but only to 73.1 percent. At Station #3 Fenitrothion levels dropped to 3.0 ug/1 and mayfly contribution was very near prespray and postspray percentages.

Sprayday periods show an inverse relationship in Diptera with a decline in contribution below prespray levels as Fenitrothion concentrations increase. Again, diversity alterations seem to stabilize when the chemical levels drop below 3.0 ug/1.

Quantitative Benthic Sampling. Benthic square foot samples show good populations of benthic insects before and after sprayday. Sprayday occurred on June 30, 1975.

Table 4. Insects per square foot; Teanaway River prespray and postspray square foot samples. Department of Ecology, 1975.

Run	Date	Square Feet	Insects/ Ft^2
Prespray	6/12/75	24 ft^2	37.8
Postspray	7/22/75	18 ft^2	37.7

Insect Live Boxes. Two insect live boxes were placed in the Teanaway River at Stations #1, #2 and #3 about two hours prior to the spray application. The stoneflies and mayflies were held in separate compartments to prevent the carnivorous stoneflies from consuming the herbivorous mayflies. Caddisfly larvae were held in the same compartment with the mayflies.

Approximately four hours after spraying, the live boxes were recovered and the live and dead insects were counted with the following results:

Table 5. Insect live box results; Teanaway River, sprayday II; Department of Ecology, July 7, 1975.

Station	Test Organism	Number Exposed	Number Survived	Percent Mortality
1	Stoneflies	20	20	0
	Mayflies	20	10	50
2	Stoneflies	20	19	5
	Mayflies	20	2	90
	Caddisflies	5	5	0
3	Stoneflies	2	2	0
	Mayflies	6	0	100
	Caddisflies	10	10	0

Although the mayfly losses were high, many of the organisms listed were simply missing. Equipment problems were encountered in this test which permitted escapes and the intermingling of mayflies and stoneflies. Only 2 mayfly carcasses were recovered, the remainder of the test insects were missing, therefore, these losses were not interpreted as negative impacts toward the Fenitrothion spray.

Fish Live Boxes. One live box containing 15 rainbow trout was placed in the Teanaway River at Station #1. No mortalities among the test fish were noted during sprayday and all of the live box fish were alive and healthy after eight hours exposure.

Stream Surveys. Stream surveys were conducted on the Teanaway River immediately prior to, during, and after the aerial spray application. During these observations, spray sensitive cards were placed along the stream bank prior to spraying and recovered shortly thereafter. DOE personnel conducting the surveys also determined that:

1. There were no physical phenomenon such as slides, flooding, etc., occurring in the stream within or above the study area that would adversely affect the project data.

2. There was no animal life wading or digging in the stream within or above the study area which would adversely affect the project data.

3. There were no dead or stressing fish or other animal life within or downstream of the study area during or after the spray application.

Poormans Creek

Poormans Creek received one application of Fenitrothion at three ounces per acre. The data shown here was collected on sprayday, July 9, 1975.

Drift Insects. The entire flow of Poormans Creek, about 0.5 cfs, was directed through a single drift net at all three sampling stations.

Spray sensitive cards indicated that the spray did enter the stream particularly at Station #1 which was located at the downstream edge of a large clearing. Spraying commenced at approximately 0500 hours and the techniques employed were similar to those used on the Teanaway.

Poormans Creek drift insect data is quite similar to the Teanaway River information, however the normal downward trend in counts after dawn is not as prominent as in the Teanaway River graphs. Fenitrothion concentrations rose from below detection levels to 31.0, 2.5 and 1.2 ug/l by 0700 hours at Stations #1, #2, and #3, respectively, just as drift insect counts began to decline. The increase in Fenitrothion concentrations seem to bring about a concurrent rise in drift insect counts which is followed by a decline in counts as Fenitrothion levels return to subdetection levels (Figures 10, 11, 12).

Diversity alterations in the Poormans Creek drift insect samples also follow the same general trend as in the Teanaway River results. Ephemeroptera contributions at sprayday Stations #1, #2, and #3 increased over prespray and postspray levels with an inverse relationship in Diptera contribution (Table 6):

Table 6. Average insect counts and average insect percent contribution by Order in Poormans Creek prespray, sprayday, and postspray drift insect samples. Department of Ecology, 1975.

		Ephemeroptera		Diptera		Trichoptera		Plecoptera		Coleoptera		Totals	
Run	Date	No.	%	No	%	No	%	No	%	No	%	No	%
Prespray	6/16	19.7	41.1	23.3	47.3	2.5	5.0	2.2	4.5	1.5	3.1	49.2	100
Sta #1	7/9	12.6	62.1	5.8	28.6	0.5	2.4	1.2	5.9	0.2	1.0	20.3	100
Sta #2	7/9	23.1	56.9	13.7	33.9	2.2	5.5	0.7	1.7	0.8	1.9	40.4	100
Sta #3	7/9	11.8	54.3	8.5	39.4	0.9	4.2	0.3	1.4	0.1	0.7	21.6	100
Postspray	7/18	6.3	31.4	9.3	46.4	1.2	6.1	2.6	13	0.6	3.1	20.0	100

Notice also that the increase in Ephemeroptera percentage contribution above prespray and postspray levels is greatest at Station #1, (62.1%), next at Station #2, (56.9%), followed by Station #3, (54.3%), while Diptera percentages are lowest at Station #1, somewhat higher at Station #2, followed by Station #3. Fenitrothion concentrations reached 31.0, 2.5 and 1.2 parts per billion at Stations #1, #2, and #3, respectively. These alterations in diversity clearly demonstrate the acute sensitivity of aquatic insects toward Fenitrothion in the aquatic environment.

Quantitative Benthic Sampling. Benthic square foot samples show good populations of aquatic insects before and after sprayday. Insect densities in Poormans Creek are somewhat below those of the Teanaway, however, habitat conditions in the Teanaway are much better for aquatic insects (Table 7):

Table 7. Insects per square foot; Poormans Creek prespray and postspray square foot samples. Department of Ecology, 1975.

Run	Date	Square Feet	Insects/ ft^2
Prespray	6/16/75	18 ft^2	22.2
Postspray	7/18/75	18 ft^2	21.3

Insect Live Boxes. Two insect live boxes were placed in Poormans Creek at Stations #1, #2, and #3 approximately two hours prior to the spray application. Each live box contained 10 stoneflies and 10 mayflies held in separate compartments. One live box containing 10 stoneflies and 10

mayflies was placed in the Twisp River to serve as the control. Approxi-- mately four hours after the Fenitrothion application, the live boxes were recovered and live and dead test organisims were counted with the following results:

Table 8. Insect live box results; Poormans Creek, Sprayday. Department of Ecology July 8, 1975.

Station	Test Organism	Number Exposed	Number Survived	Percent Mortality
1	Stoneflies	20	20	0
	Mayflies	20	16	20
2	Stoneflies	20	20	0
	Mayflies	20	20	0
3	Stoneflies	20	20	0
	Mayflies	20	20	0
Control,	Stoneflies	10	10	0
	Mayflies	10	10	0

The 20 percent loss in test organisms at Station #1 was considered to be a negative impact resulting from the Fenitrothion Aerial Spray Project. This determination was made because four dead mayflies were recovered from the two insect live boxes at Station #1, and the control live box in the Twisp River suffered no test organism loss (Table 8). All of the test organisims survived at Station #2, and #3, where Fenitrothion concentrations were considerably lower than Station #1.

Fish Live Boxes. One live box containing 15 rainbow trout was placed in Poormans Creek between Station #1 and Station #2. No mortalities or stressing fish were noted among the test organisms during spray application and all of the test trout were alive and healthy eight hours after spraying.

Stream Surveys. Stream surveys were conducted on Poormans Creek immediately prior to, during, and after the aerial spray application. As on the Teanaway River, spray sensitive cards were distributed along the stream and the surveys produced identical results.

DISCUSSION

The 1975 Spruce Budworm/Fenitrothion Aerial Spray Project was conducted by the U.S. Forest Service in the Okanogan and Wenatchee National Forests to determine the efficacy of the organophosphate Fenitrothion toward the western spruce budworm. Equally important was the task of determining the impact that the chemical would have on nontarget organisms, particularly aquatic insect larvae. Department of Ecology personnel conducting the impact studies made a dedicated effort to detect threshold responses of the aquatic organisms toward Fenitrothion which required meticulous sampling and sample processing techniques due to the minute application rates and the rapid degrading qualities of the chemical.

U.S. Forest Service personnel closely supervised the application of the pesticide in helicopters from the air while scientists collected water and organism samples from the program streams. Permissible spray criteria was based on 70 percent development of the spruce budworms to the fifth instar stage in their life cycle. The streams were not buffered, permitting the chemical to enter their watercourses at a consistent and known rate.

Spray sensitive cards were placed along the creek on sprayday to show whether or not the Fenitrothion entered the water. Chemical extractions and gas chromatography were utilized to provide a more precise estimate of the chemical concentration in the stream waters.

Biological investigations were employed to assess the impacts of the Fenitrothion on the aquatic environment. Drift insect samples were collected hourly to monitor threshold changes in insect activity resulting from the introduction of the chemical into the watercourses, and insect live boxes served as indicators of insect mortality by Order that occurred over the spray period. Benthic square foot samples provided a before and after sprayday population estimate permitting a mortality assessment in the event of a serious aquatic insect kill. Stream surveys were conducted to insure that stream conditions remained stable during the sampling period.

The resulting data shows that the aerial application of Fenitrothion had little, if any, measurable impact on the aquatic environment, but seems to have caused a subtle but detectable threshold of activity among the aquatic insects, particularly mayflies (Ephemeroptera). The acute sensitivity of mayflies toward Fenitrothion can be expected because Ephemeroptera are one of the most responsive aquatic insect larvae to degrading water quality. Many species are grazing herbivores inhabiting exposed surfaces which opens them to whatever the stream waters are transporting. The introduction of a toxic material in low concentrations does not always kill them outright, but it may excite or disorient them to the extent that they leave their habitat niche to drift in the stream. This reaction on the part of the mayflies causes an alteration of insect diversity in the drift samples in the form of an increase in the contribution of Ephemeroptera and a concurrent decrease in the contribution of other aquatic insect Orders.

The majority of the drift insect data collected from the program streams shows a normal decline in insect counts per cubic feet of flow after dawn, an increasing trend as Fenitrothion concentrations rise followed by a decline in insect counts as Fenitrothion concentrations return to subdetection levels (Figures 6, 7, 8, 11, 12). Although the increase in drift insect counts per cubic feet of flow are relatively minor, they are detectable and seem relatable to the rise in Fenitrothion concentrations in the program streams. This relationship becomes more apparent when insect diversity in the prespray drift insect samples are compared to those of the sprayday samples (Tables 3 and 6).

Although not dramatic, diversity alterations in the drift insect samples are apparent and are directly relatable to the introduction of Fenitrothion. Ephemeroptera contribution increased significantly on sprayday (Stations #1, #2, #3) above prespray levels in the Teanaway River and Poormans Creek drift insect samples (Tables 3 and 6). The greatest increases occurred at Station #1 where Fenitrothion concentrations were highest, declining at Station #2 and Station #3 as chemical concentrations drop below detection levels. These trends are quite consistent throughout the program stream data.

These data, and 20 percent mayfly mortality that occurred in the Poormans Creek Station #1 insect live boxes clearly demonstrate the sensitivity of Ephemeroptera toward Fenitrothion. It also suggests that the Fenitrothion Aerial Spray Project did impose an impact at threshold levels on the aquatic insects in some of the program streams. From all indications the impact was minor affecting primarily Ephemeroptera.

The benthic square foot samples show good populations of insects in the program streams before and after sprayday (Tables 4 and 7). No dead or stressing fish were observed in the live boxes in the wild during or after spray application.

CONCLUSIONS

Although there appeared to be a detectable impact on the aquatic environment at threshold levels resulting from the 1975 Spruce Budworm Fenitrothion Aerial Spray Project, it was concluded that no measurable environmental damage was incurred by the aquatic biota of the program streams. Of the six spray applications monitored that involved watercourses, mortalities resulting from the Fenitrothion Spray Project were noted only in live boxes at Station #1 on Poormans Creek. No insect mortalities were noted in the free flowing stream or in the drift insect samples that could be attributed to the aerial spray project.

It was also concluded that aquatic insects, particularly mayflies, are quite sensitive to Fenitrothion at relatively low concentrations. A high degree of buffer protection is recommended for Fenitrothion application rates in excess of three ounces per acre.

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The authors,

Harry B. Tracy
and
Bill Purvis

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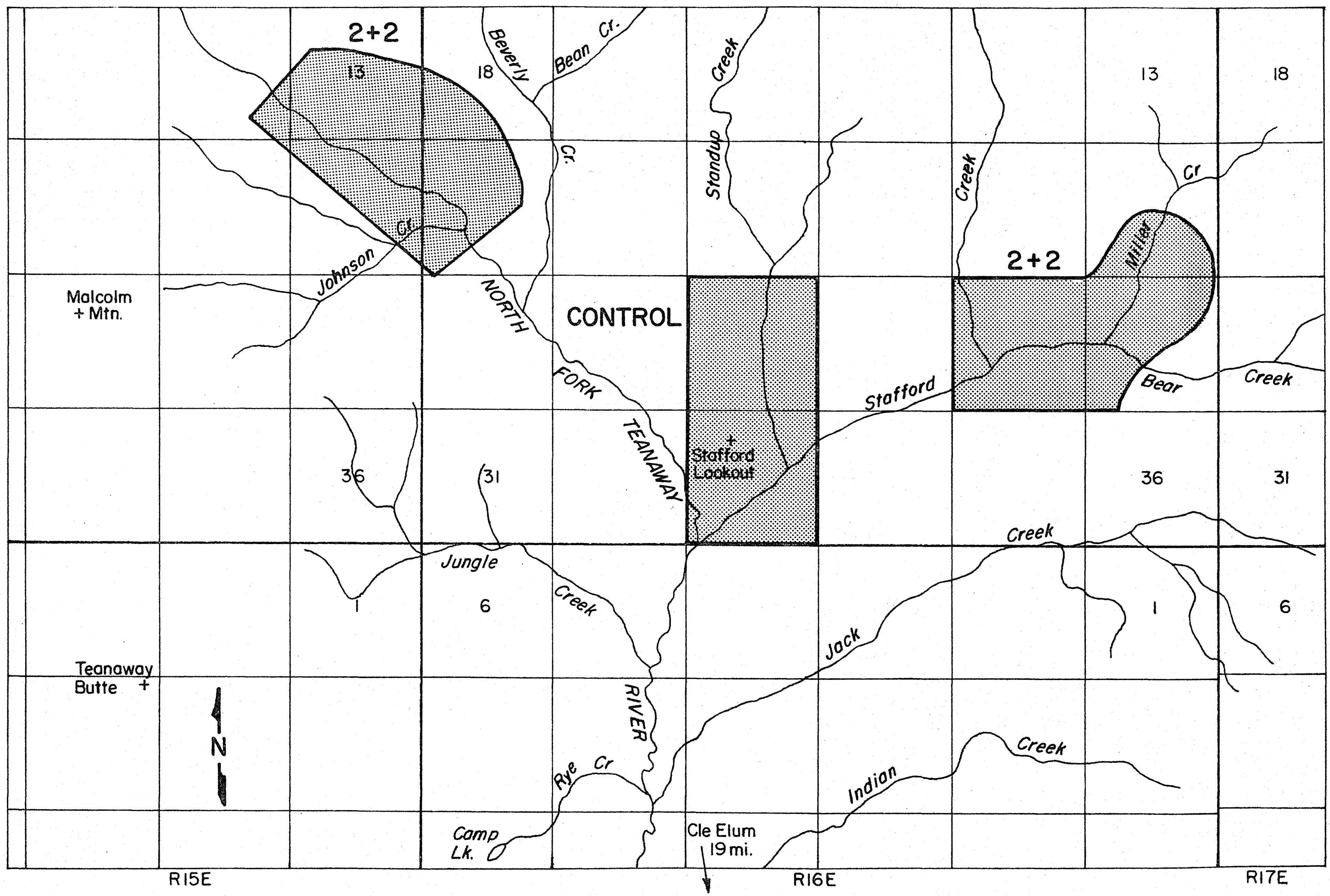

Figure I. MAP OF CLE ELUM SPRAY AREA; 1975 SPRUCE BUDWORM FENITROTHION AERIAL SPRAY PROJECT.

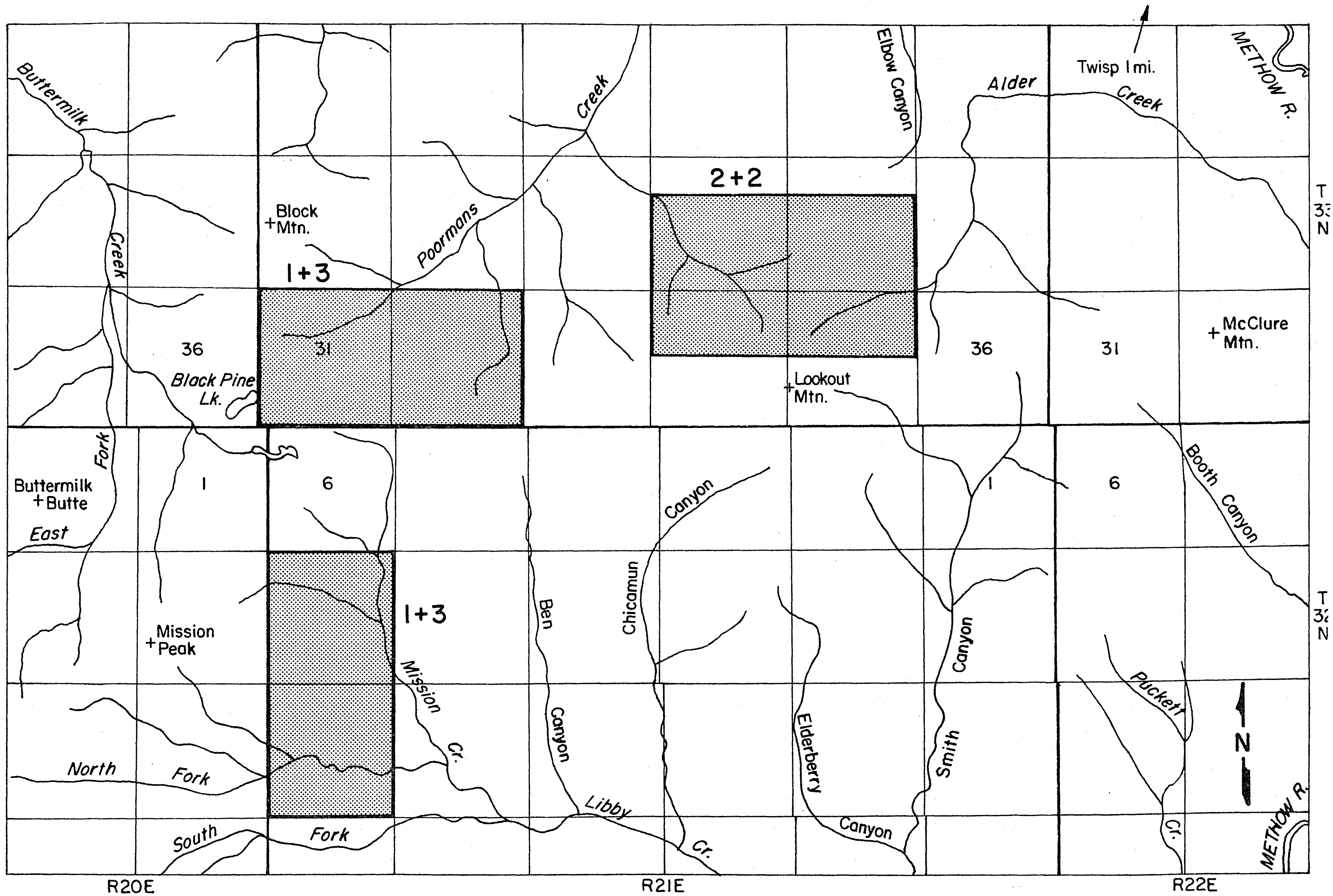

Figure 2. MAP OF TWISP SPRAY AREA. 1975 SPRUCE BUDWORM FENITROTHION AERIAL SPRAY PROJECT.

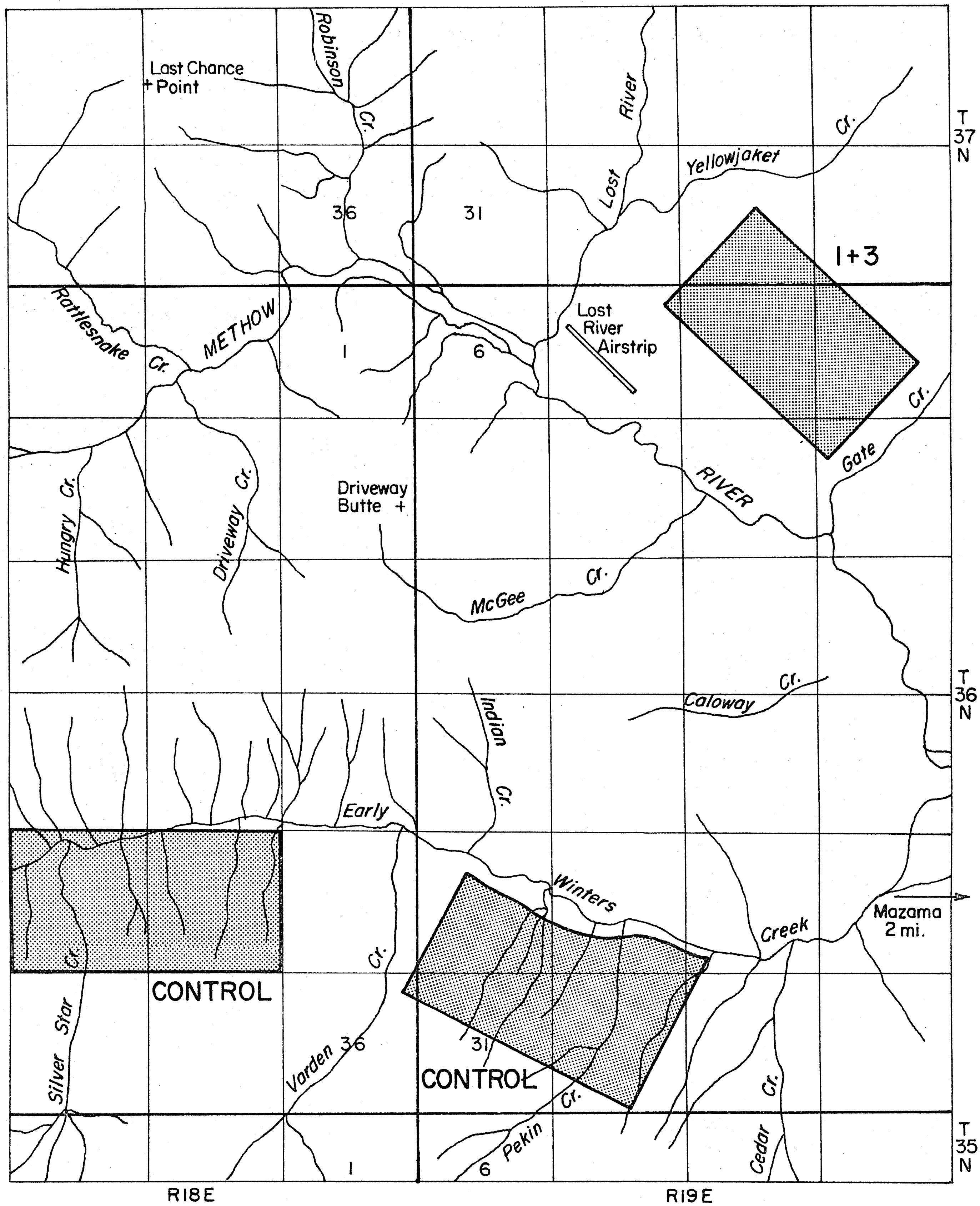

Figure 3. MAP OF MAZAMA SPRAY AREA. 1975 SPRUCE BUDWORM FENITROTHION AERIAL SPRAY PROJECT.

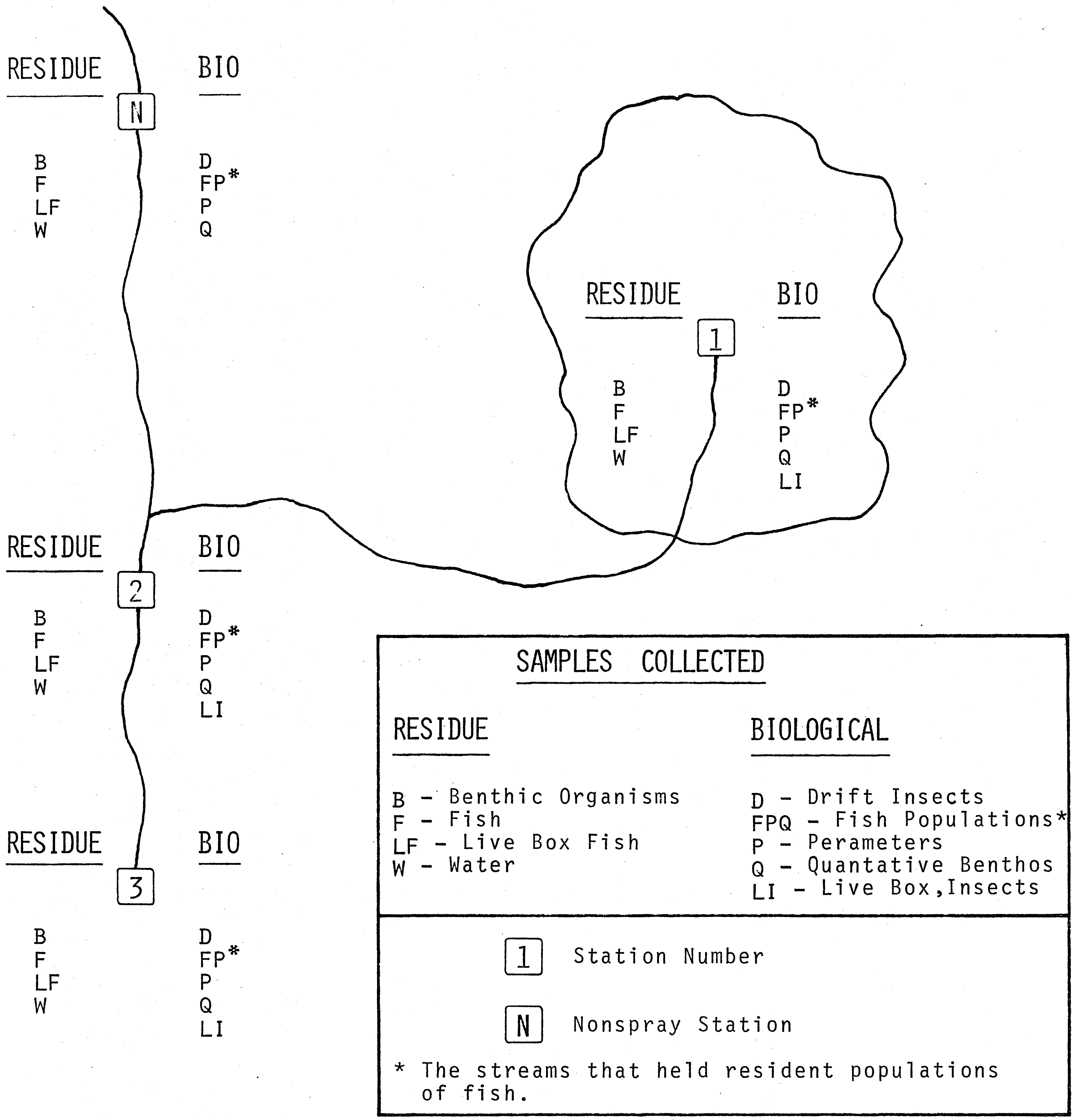

FIGURE 4. SAMPLING STATION LAYOUT AND SAMPLES COLLECTED: ONE INDEX STREAM AND ONE NONSPRAY STATION. THE 1975 SPRUCE BUDWORM FENITROTHION AERIAL SPRAY PROJECT, DEPARTMENT OF ECOLOGY, 1975.

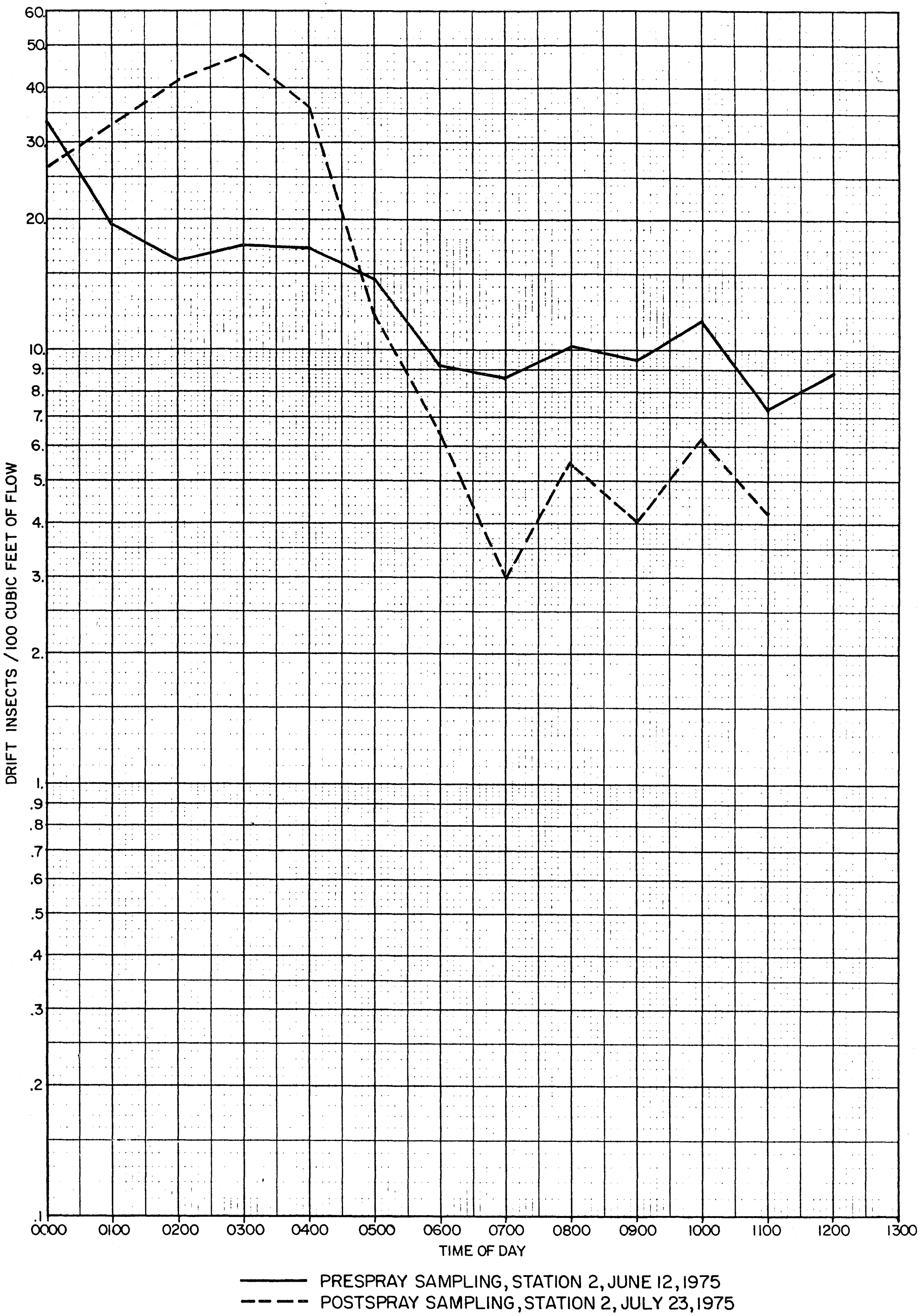

Figure 5. DRIFT INSECT PRESPRAY AND POSTSPRAY SAMPLING. TEANAWAY RIVER, INSECTS PER 100 CUBIC FEET OF FLOW.

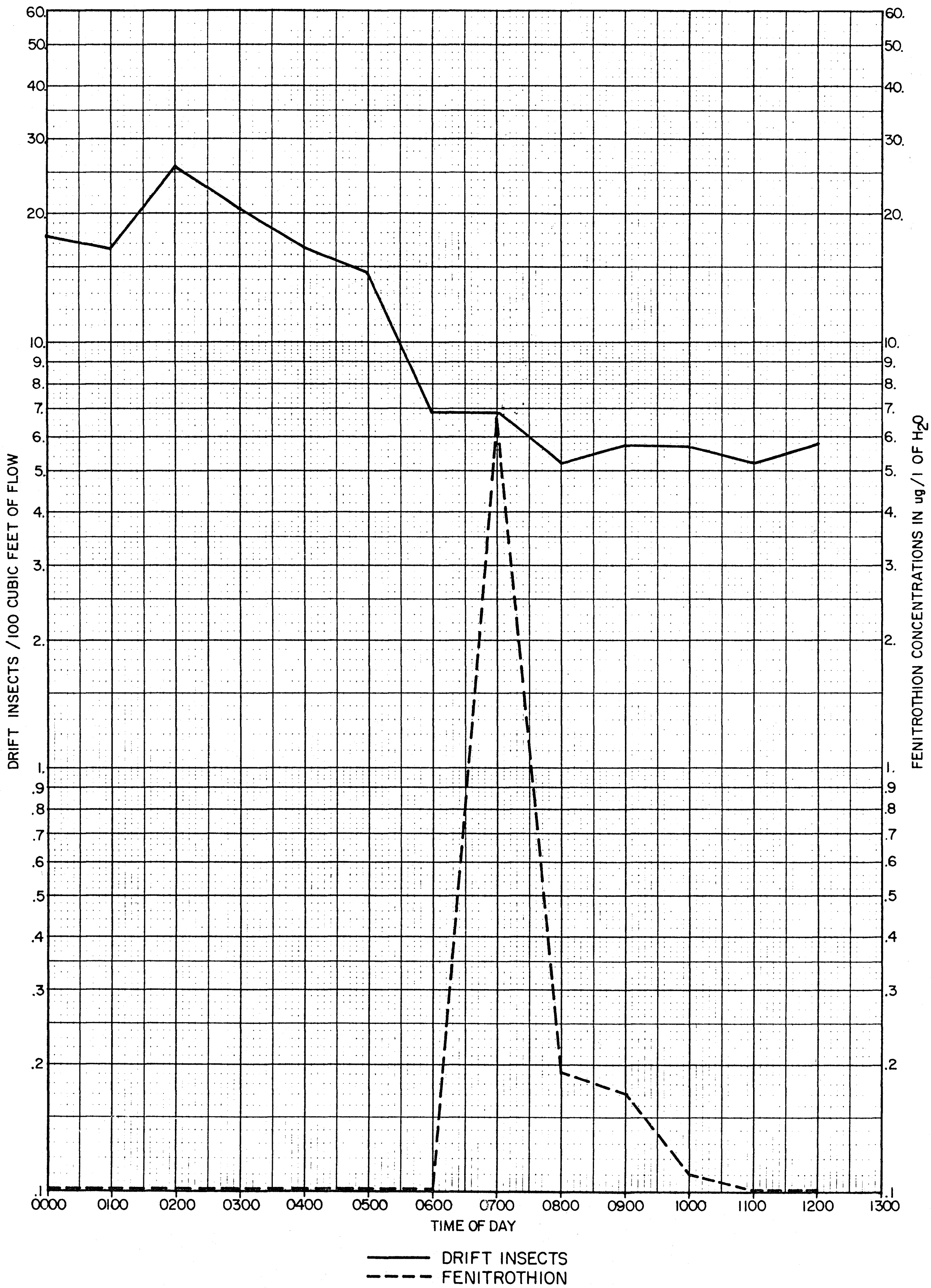

Figure 6. DRIFT INSECT SAMPLING. TEANAWAY RIVER, SPRAY DAY II, STATION I, JULY 7, 1975. INSECTS PER 100 CUBIC FEET OF FLOW AND FENITROTHION CONCENTRATIONS IN ug/l OF WATER.

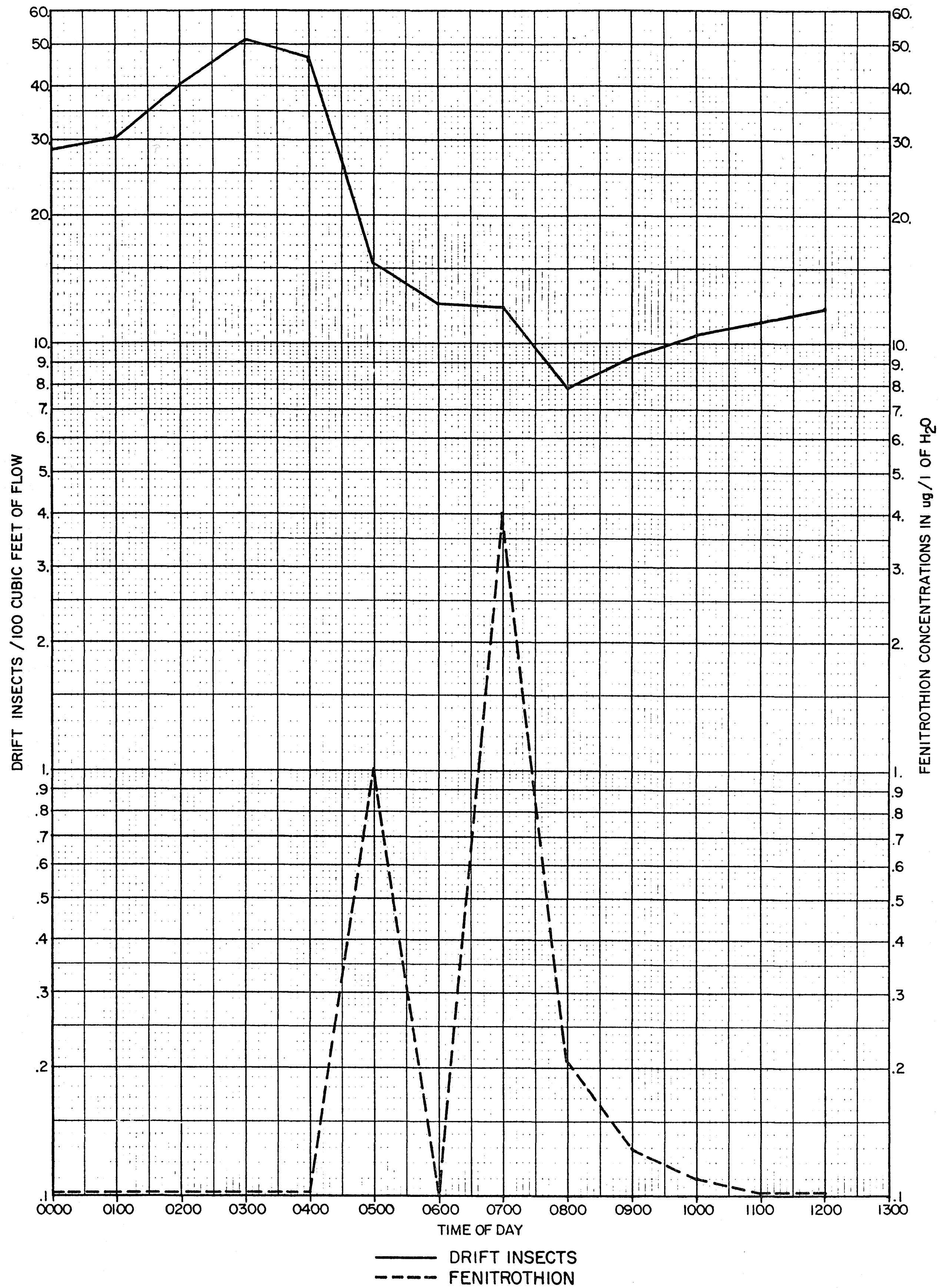

Figure 7. DRIFT INSECT SAMPLING. TEANAWAY RIVER, SPRAY DAY II, STATION 2, JULY 7, 1975. INSECTS PER 100 CUBIC FEET OF FLOW AND FENITROTHION CONCENTRATIONS IN ug/l OF WATER.

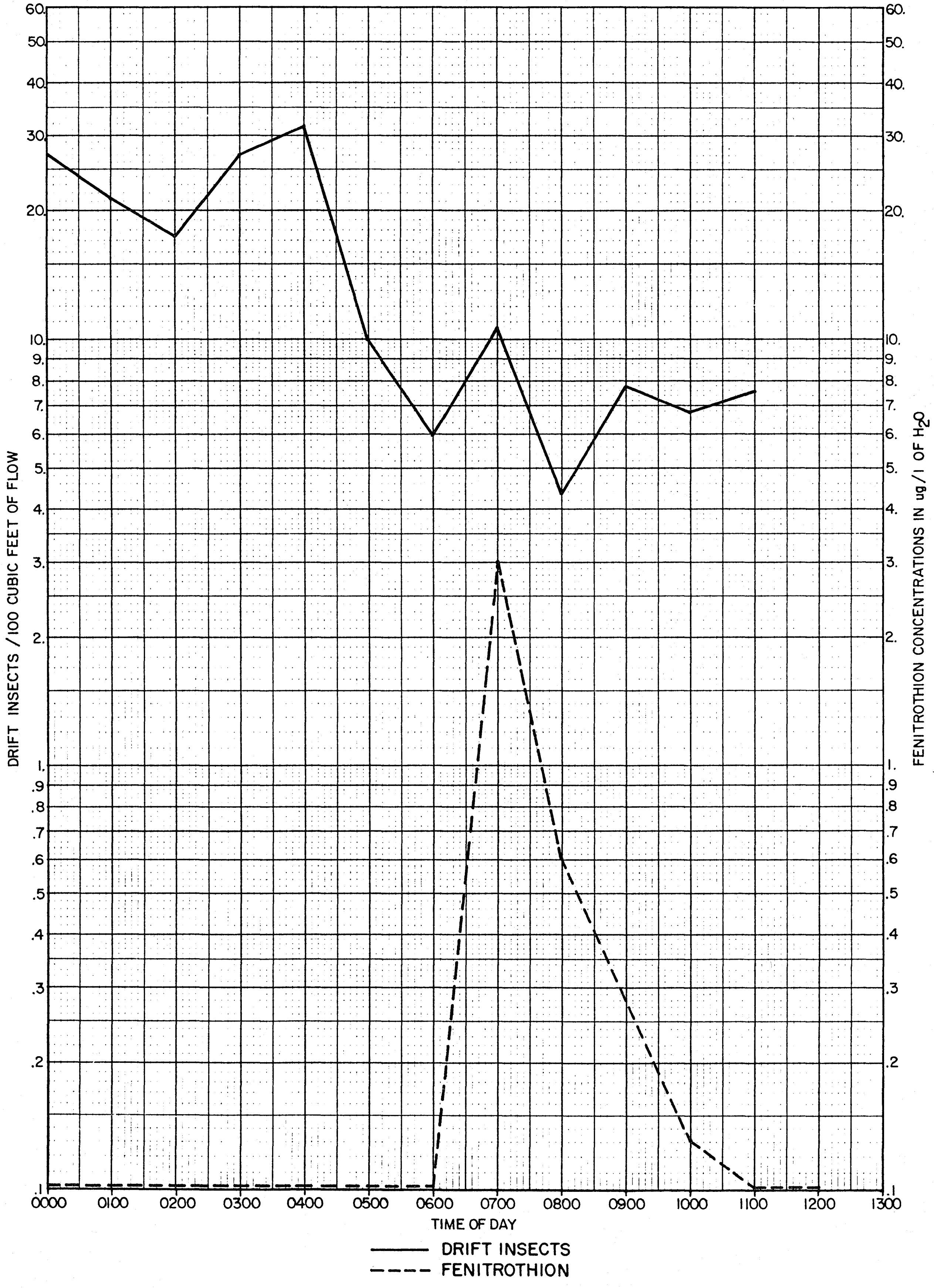

Figure 8. DRIFT INSECT SAMPLING. TEANAWAY RIVER, SPRAY DAY II, STATION 3, JULY 7, 1975. INSECTS PER 100 CUBIC FEET OF FLOW AND FENITROTHION CONCENTRATIONS IN ug/l OF WATER.

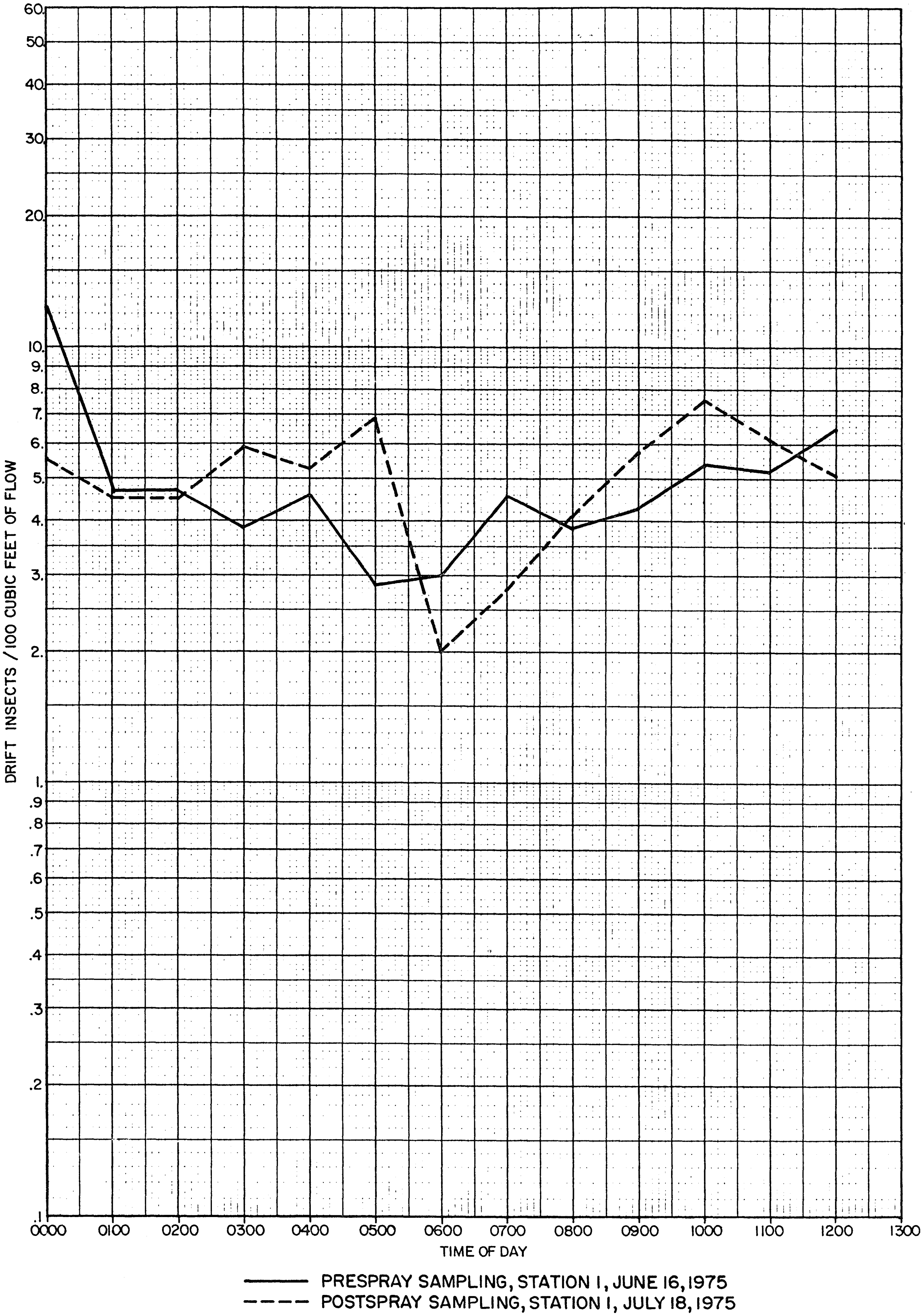

Figure 9. DRIFT INSECT PRESPRAY AND POSTSPRAY SAMPLING. POORMANS CREEK, INSECTS PER 100 CUBIC FEET OF FLOW.

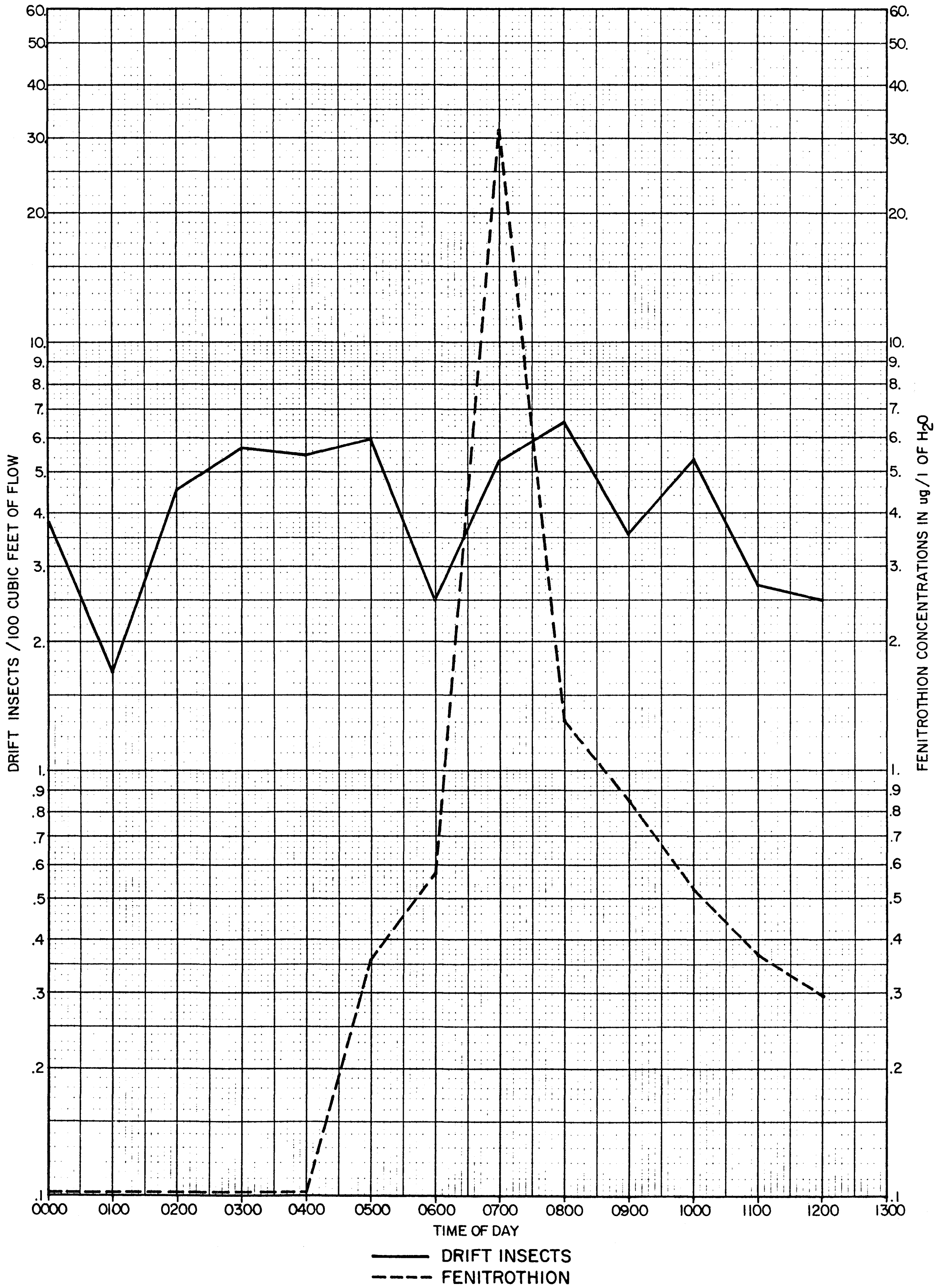

Figure 10. DRIFT INSECT SAMPLING. POORMANS CREEK, SPRAY DAY, STATION 1, JULY 9, 1975. INSECTS PER 100 CUBIC FEET OF FLOW AND FENITROTHION CONCENTRATIONS IN ug/l OF WATER.

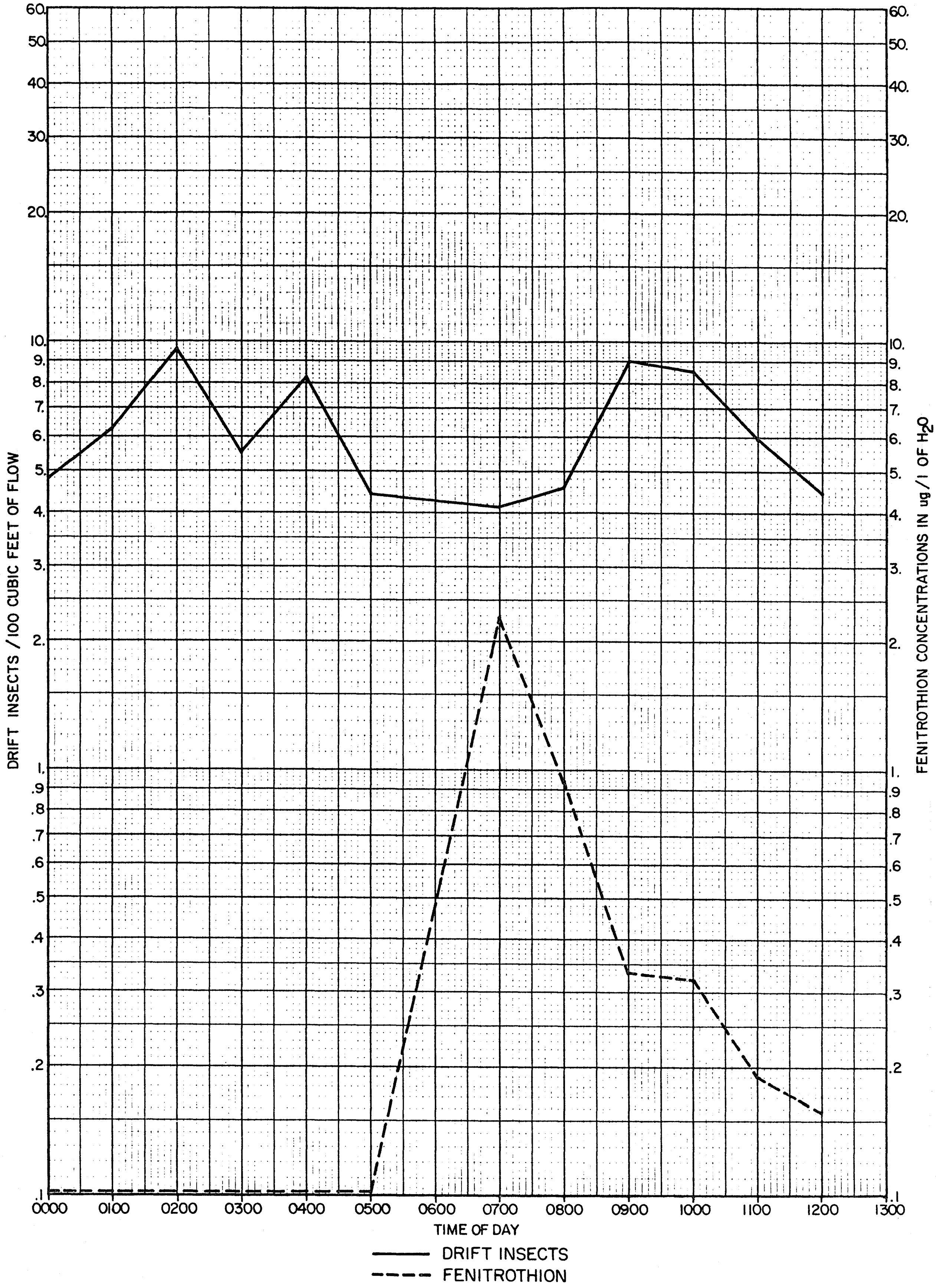

Figure 11. DRIFT INSECT SAMPLING. POORMANS CREEK, SPRAY DAY, STATION 2, JULY 9, 1975. INSECTS PER 100 CUBIC FEET OF FLOW AND FENITROTHION CONCENTRATIONS IN ug/l OF WATER.

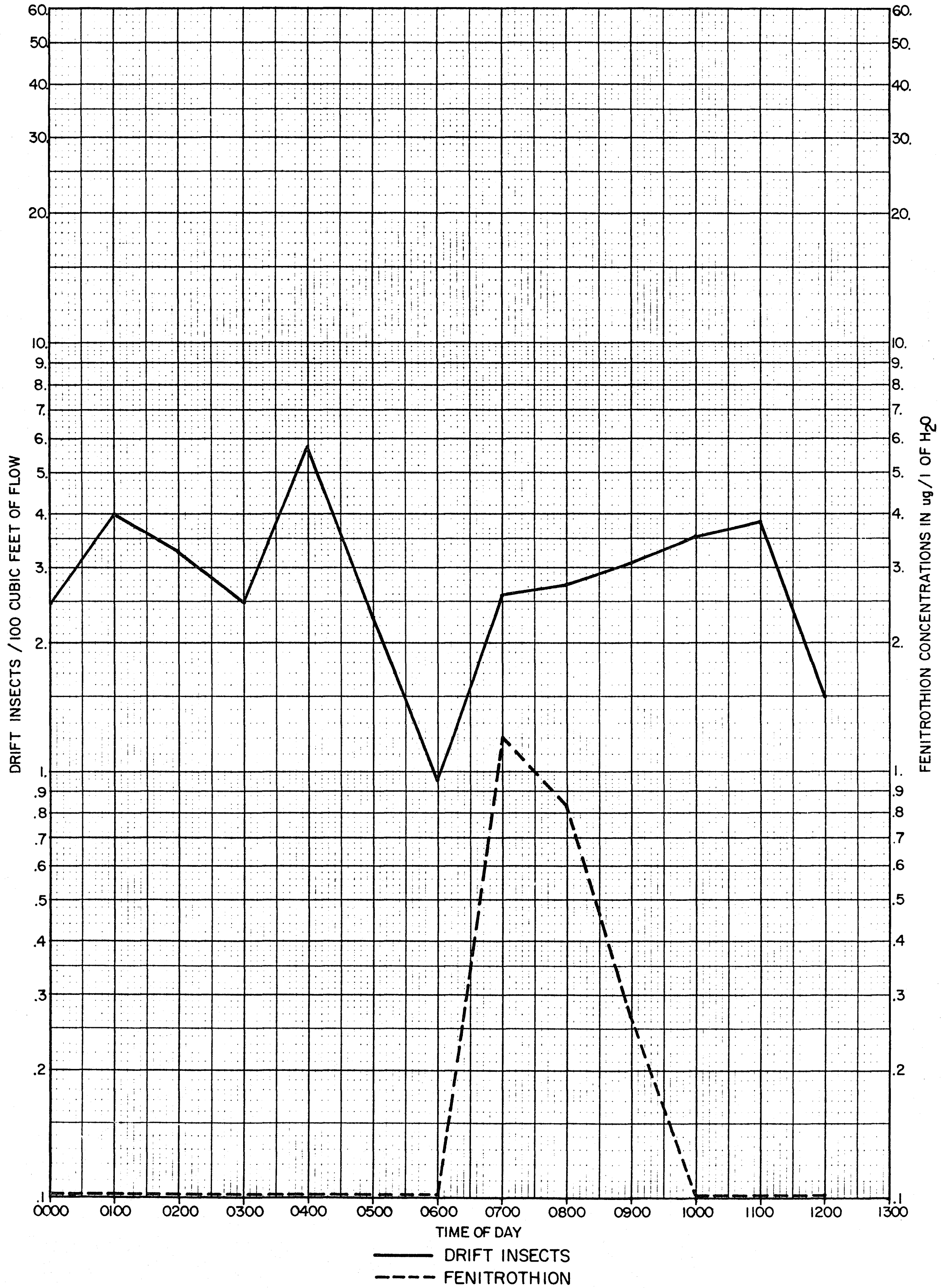

Figure 12. DRIFT INSECT SAMPLING. POORMANS CREEK, SPRAY DAY, STATION 3, JULY 9, 1975. INSECTS PER 100 CUBIC FEET OF FLOW AND FENITROTHION CONCENTRATIONS IN ug/l OF WATER.